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Economy of
High-Speed Steel Tools

Electrical Engineering

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THE ECONOMY OF HIGH-SPEED STEEL TOOLS

BY

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Thesis for Degree of Bachelor of Science
in Electrical Engineering

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May 26, 1905.

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Hibbard Spencer Greene and Fred D. Smith

ENTITLED The Economy of High-Speed Steel Tools

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science in Electrical Engineering.

Morgan Brooks

HEAD OF DEPARTMENT OF Electrical Engineering.



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THE ECONOMY OF HIGH SPEED STEEL TOOLS.

The experiments for this thesis were carried on in the locomotive shops of the C.&E.I. Ry. at Danville, Ill. these shops have been completed only about ten months and the machine tools are the latest and most approved types for high speed work, and all the large tools are of the direct motor driven type. High speed steel tools are used on practically every machine in the shop, as the management is very up to date and fully appreciates the merit of this kind of tool steel.

The object of our experiments was to make a study of the relative cost of using high speed and low speed steel tools.

To do this and to get a just basis of comparison, we selected for each machine tool used, two pieces of work as nearly identical as possible. All of the tests were run on standard jobs such as are used every day in railroad shops. One of these jobs was then run through with a high speed steel tool and the other with a low speed steel tool. The time and the power per pound of metal removed, also the cost of power and labor per pound of metal removed was figured.

The method of measuring the power consumed was, in most cases, to put an ammeter in the circuit just outside the controller with a voltmeter across the line. Readings of these instruments were taken not less than one every two minutes, and often every minute. The average values of current were then found by the use of an adding machine, this greatly facilitating our work. The power was then found by taking the product of the average pressure and the average current. For the planer job, however, where the power fluctuated too much to use scale instruments, a Thomson recording wattmeter was used. Time, from which cost of labor and K.W.hrs. were determined, was carefully kept. The speed of the cut was measured with a Weston cutmeter, and these readings checked by counting the revolutions and figuring the speed from the diameter of the piece being turned. The depth of cut and the feed was measured for each job by the machinist.

Before commencing a test, the machine tool and the floor underneath were carefully cleaned in order to obtain the exact amount of metal removed for the one job. After the test, the metal was carefully cleaned up by the helpers and weighed under our supervision.

The results of the test are given on data sheets

1 and 2, and a more minute description of each test and its results are given later. A graphical comparison of the economies of the two steels as used in the Danville shops is given for each test on data sheets 4 to 10. In this graphical comparison, the cost of labor is figured at \$.33 per hour and the cost of power at \$.0165 per K.W.hr., these being the prices of labor and power at the Danville shops. Cost of power was figured very carefully, all possible items being considered. The cost of the building was obtained from the Chicago offices, the cost of coal, oil, waste and labor from the Danville offices. Cost of water was given us by the Danville Water Company, the cost of equipment was given us by The Arnold Company, the constructing engineers. The average K.W.hrs. per day was determined from five daily readings of the integrating wattmeter on the power plant switchboard, taken by the chief engineer of the power plant.

From the data thus obtained, as shown on data sheet 3, the cost per K.W.hr. was figured as \$.0162 . To allow for small losses not considered, a cost per K.W.hr of \$.0165 was used in the computations.

TEST NO. 1. LOW SPEED STEEL TOOL.(a) ON AXLE LATHE.

The machine tool used in this test was a Pond Lathe 52" swing direct connected to a 6 H.P. G.E. motor with G.E. rheostatic control.

The job was a locomotive driving axle 72" x 10", Taylor iron.

A cut was taken on each end for the fits, 18", a cut of 1/8" and a feed of 1/32" was used here, cutting speed of 25' per minute.

A roughing cut was taken on the rest of the axle with a 1/2" cut and a 1/64" feed, cutting speed of 25' per minute.

A finishing cut was taken on each end of the axle for the journals, the cut used here was about 1/16" and the feed was 1/64", cutting speed of 25' per minute.

Each of the journals were rolled, cutting speed of 25' per minute.

Weight of metal removed was 204.5 pounds.

Time was 15 hours and 7 minutes.

Total power was 26.45 K.W.hrs.

Cost of power per pound of metal was \$.00213

Cost of labor per pound of metal was \$.0244

Total cost of removing a pound of metal was \$.02653

TEST NO 2. HIGH SPEED STEEL TOOL.(a) ON AXLE LATHE.

The machine used in this test was a Pond Lathe, 52" swing, direct connected to a 6 H.P. G.E. motor with G.E. rheostatic control.

The job was a locomotive driving axle 72" x 10", Taylor iron.

A cut was taken on each end for the fits, a feed of $3/64$ " a cut of $1/8$ " and a cutting speed of 80' per minute being used here.

A roughing cut was taken on the rest of the axle with a $1/2$ " cut and a $3/64$ " feed and a cutting speed of 77' per minute.

A finishing cut was taken on each end of the axle for journals with a cut of about $1/16$ " and $1/64$ " feed and a cutting speed of 77' per minute.

Each of the journals was rolled.

Weight of metal removed was 209.3 pounds.

Time was 3 hours and 33 minutes.

Total power was 9.18 K.W.hrs.

Cost of power per pound of metal removed was \$.000724

Cost of labor per pound of metal removed was \$.00559

Total cost of removing a pound of metal was \$.00631

COMPARISONS OF TESTS 1 AND 2.

Three times as much power was required per pound of metal removed for the low speed as was required for the high speed steel.

4.4 times as much time was required per pound of metal removed for the low speed as was required for the high speed steel.

The cost of removing a pound of metal with the low speed steel was 4.3 times as much as with the high speed steel.

TEST NO 3. LOW SPEED STEEL TOOL. (b) ON WHEEL LATHE.

The machine tool used in this test a 84" Pond Wheel Lathe direct connected to a 20 H.P. double commutator Commercial motor, with Commercial control.

The job was turning down a pair of 53 1/4" locomotive drivers of Standard steel.

A roughing cut was first taken and scraped for finishing.

The speed of cut was 4.4' per minute.

Weight of metal removed was 265 pounds.

The time was 6 hours and 27 minutes.

Total power was 18.49 K.W.hrs.

Cost of power per pound of metal removed was \$.00115

Cost of labor per pound of metal removed was \$.00803

Total cost of removing a pound of metal was \$.00918

TEST NO 4. HIGH SPEED STEEL TOOL (a) ON WHEEL LATHE.

The same machine and the same job as in test 3.

A roughing cut was taken with a cut of 5/32" and a feed of 5/8" cutting speed of 14' per minute.

Scraped at a speed of 8' per minute.

Weight of metal removed was 335 pounds.

Time was 2 hours and 8 minutes.

Total power was 21.63 K.W.hrs.

Cost of power per pound of metal removed was \$.001066

Cost of labor per pound of metal removed was \$.00114

Total cost of removing a pound of metal was \$.0022

COMPARISONS OF TESTS 3 AND 4.

The cost of power for the low speed steel was 1.08 times that for the high speed.

The cost of labor for the low speed steel was 7.08 times that for the high speed.

The total cost per pound of metal removed with the low speed steel was 4.15 times that for the high speed.

TEST NO 5. LOW SPEED STEEL TOOL (a) ON HORIZONTAL BORING MILL

The machine tool used in this test was a small Betts Boring Mill, direct connected to a 7.5 H.P., double commutator Commercial motor, Commercial control.

The job was boring out cast iron journals, from 3-3/16" to 3-13/16" x 6.5"

A roughing cut was first taken with a 1/32" feed, cut 1/4" and with a cutting speed of 7.5' per minute.

A finishing cut was taken with 1/32" feed, 1/32" cut, and a cutting speed of 7.5' per minute.

Weight of metal removed was 4.75 pounds.

Time was 42 minutes.

Total power was .784 K.W.hrs.

Cost of power per pound of metal removed was \$.00273

Cost of labor per pound of metal removed was \$.0486

Total cost of removing a pound of metal was \$.05133

TEST NO 6 HIGH SPEED STEEL TOOL (b) ON HORIZONTAL BORING MILL

The same machine tool and the same job was used as in test 5.

A roughing cut was taken, $5/256$ " feed, cut $1/4$ ", and with a cutting speed of 36' per minute.

A finishing cut was taken with a $1/32$ " cut, $5/256$ " feed and with a cutting speed of 36' per minute.

Weight of metal removed was 4.75 pounds.

Time was 8.15 minutes.

Total power was .367 K.W.hrs.

Cost of power per pound of metal removed was \$.00127

Cost of labor per pound of metal removed was \$.00945

Total cost of removing a pound of metal was \$.01072

COMPARISON OF TESTS 5 AND 6.

Cost of power for the low speed tool was 2.15 times that for the high speed tool.

Cost of labor for the low speed tool steel was 5.15 times that for the high speed tool steel.

The total cost of removing a pound of metal with the low speed steel tool was 4.8 times that for the high speed steel tool.

TEST NO 7. LOW SPEED STEEL TOOL.(a) ON VERTICAL BORING MILL.

The machine tool used in this test was a Niles Vertical Boring Mill, with two tools, direct connected to a 7.5 H.P. double commutator Commercial motor, with Commercial control.

The job was a 44" engine driver tire, Latrobe steel.

The cut was $3/32$ ", the speed of cut was 20' per minute.

The weight of metal removed was 13.5 pounds.

Time was 1 hour and 33 minutes.

Total power was 1.765 K.W.hrs.

Cost of power per pound of metal removed was \$.00218

Cost of labor per pound of metal removed was \$.0384

Total cost of removing a pound of metal was \$.04058

TEST NO 8. HIGH SPEED STEEL TOOL.(b&c) ON VERTICAL BORING MILL

The same machine tool and the same job was used as in test No 7.

The cut was $3/32$ ", the speed of cut was 35' per minute.

Weight of metal removed was 13.5 pounds.

Time was 27.5 minutes.

Total power was 1.463 K.W.hrs.

Cost of power per pound of metal removed was \$.00181

Cost of labor per pound of metal removed was \$.01135

Total cost of removing one pound of metal was \$.01316

COMPARISON OF TESTS 7 AND 8.

The cost of power for the low speed steel tool was 1.2 times that for the high speed steel tool.

The cost of labor for the low speed steel tool was 3.4 times that of the high speed steel tool.

The total cost of removing a pound of metal with the low speed steel tool was 3.1 times that for the high speed steel tool.

TEST NO 9. LOW SPEED STEEL TOOL.(b) ON COACH WHEEL LATHE.

The machine tool used in this test was a Pond Coach Wheel Lathe, direct connected to a 15 H.P.G.E.motor, with G.E. rheostatic control.

The job was turning down a pair of 36" coach wheel tires, Midvale steel.

The cut was $3/8$ " and the speed of the cut was 9.5' per minute.

No scraping was done on this job.

Weight of metal removed was 83 pounds.

Time was 2 hours and 43 minutes.

Total power was 9.226 K.W.hrs.

Cost of power per pound of metal removed was \$.00184

Cost of labor per pound of metal removed was \$.01313

Total cost of removing a pound of metal was \$.01497

TEST NO 10. HIGH SPEED STEEL TOOL (b) ON COACH WHEEL LATHE.

The same machine tool and job as in test No 9.

The cut was $3/8$ ", the feed was $1/8$ ", the speed of cut was 15' per minute.

Weight of metal removed was 160 pounds.

Time was 2 hours and 31 minutes.

Total power was 15.37 K.W.hrs.

Cost of power per pound of metal removed was \$.001587

Cost of labor per pound of metal removed was \$.00516

Total cost of removing a pound of metal was \$.00674

COMPARISONS OF TESTS 9 AND 10.

The cost of power for the low speed steel tool was 1.16 times that for the high speed steel tool.

The cost of labor for the low speed steel tool was 2.55 times that for the high speed steel tool.

The total cost of removing a pound of metal with the low speed steel tool was 2.2 times that for the high speed steel tool.

TEST NO 11. LOW SPEED STEEL TOOL (b) ON POND WHEEL LATHE.

The machine used in this test was a 84" Pond Wheel Lathe, direct connected to a 20 H.P. Commercial, double commutator motor, with Commercial control.

The job was turning down a pair of locomotive driver tires 78", Latrobe steel.

A roughing cut was taken with $3/8"$ cut, a $1/16"$ feed, and the speed of cut was 7' per minute.

The tires were scraped to finish.

Weight of metal removed was 178 pounds.

Time was 3 hours and 58 minutes.

Cost of power per pound of metal removed was \$.00139

Cost of labor per pound of metal removed was \$.0073

Total cost of removing a pound of metal was \$.00869

TEST NO 12. HIGH SPEED STEEL TOOL (b) ON POND WHEEL LATHE.

The same machine tool and the same job as in test No 11.

A roughing cut was taken with a $3/8"$ cut, feed of $3/16"$, with a cutting speed of 16.5' per minute.

The tires were scraped to finish.

Weight of metal removed was 178 pounds.

Time was 1 hour and 52 minutes.

Cost of power per pound of metal removed was \$.000465

Cost of labor per pound of metal removed was \$.00346

Total cost of removing a pound of metal was \$.00389

COMPARISONS OF TESTS 11 AND 12.

The cost of power for the low speed steel tool was 2.98 times that for the high speed steel tool.

The cost of labor for the low speed steel tool was 2.11 times that for the high speed steel tool.

The total cost of removing a pound of metal for the low speed steel tool was 2.23 times that for the high speed steel tool.

TEST NO 13. LOW SPEED STEED TOOL (a) ON THE PLANER.

The machine tool used in this test was a William Gleason Planer, 42" x 42" x 12', belt driven from a 7.5 H.P. Commercial motor mounted on planer, with G.E. control.

The job was facing 5 cast iron driving boxes.

A cut of 1/4" with a feed of 1/16" was taken with a cutting speed of 12.5' per minute.

Weight of metal removed was 45 pounds.

Time was 3 hours and 15 minutes.

Cost of power per pound of metal removed was \$.00134

Cost of labor per pound of metal removed was \$.0238

Total cost of removing a pound of metal was \$.02514

TEST NO 14. HIGH SPEED STEEL TOOL (a) ON PLANER.

The same machine tool and the same job as in test No 13.

A cut of 5/16" with a feed of 1/8" and a cutting speed of 18' per minute was taken.

Weight of metal removed was 45 pounds.

Time was 1 hour and 5 minutes.

Cost of power per pound of metal removed was \$.000671

Cost of labor per pound of metal removed was \$.00795

Total cost of removing a pound of metal was \$.00862

COMPARISONS OF TESTS 13 AND 14.

The cost of power for the low speed steel tool was 2 times that for the high speed steel tool.

The cost of labor for the low speed steel tool was 3 times that for the high speed steel tool.

The total cost of removing a pound of metal with the low speed steel tool was 2.93 times that for the high speed steel tool.

CONCLUSIONS.

From the data collected, it is seen that the actual cost of removing a pound of metal with low speed steel tool , was from 2.2 to 4.8 times the cost, when using the high speed steel tool. Besides this very apparent saving in power and labor, there is another saving due to the fact that from one fourth to one half the number of machine tools usually employed will do the work if high speed steel tools are used in the shop . This very materially cuts down the first cost of machinery for a given shop. Of course, the machine tools for high speed steel have to be built much heavier and therefore cost much more, but there is still a large margin of saving. The smaller investment also makes the depreciation on the plant much smaller and this is a very important factor , since the depreciation on such tools is often figured as high as ten per-cent. A new shop using high speed steel tools can be built to do a certain amount of work with much less floor space than if low speed steel tools were used. The floor space of an old shop can also be increased by throwing out the low speed steel machine tools and installing a much less number of the high speed steel tools.

Much credit is due Professor Williams of The University of Illinois, under whom this thesis work was done, for obtaining the permission of the C. & E. I. Ry. to do the work in their shops, and also for the suggestions he made from time to time and the interest that he took in the work.

Thanks are due to Mr George B. Smith, former Superintendant and to Mr S. T. Parks, former Master Mechanic. These men allowed the use of their shops for the tests and then gave orders to the machine shop Superintendant to do all in his power to help us. This man, Mr Walter Smith, was at all times ready to allow us to go ahead on any test that we chose, and saw to it personally that the machinist and helpers were under our orders while running a test. The hearty cooperation of the following machinist who ran the tools during the tests, and who did their best to get good results, was much appreciated.

Mr Palmer,

Mr Martin,

Mr Cook,

Mr Carter,

Mr Morris,

Mr Fagan.

Mr L. E. Fisher, manager of The Illinois Traction System was kind enough to furnish us with transportation to and from Danville.

H. S. Greene,

F. D. Smith.

KEY TO TOOL STEELS USED.

Low Speed (a) Water Hardened.

Low Speed (b) Low Speed Mushet.

High Speed (a) High Speed Styrian.

High Speed (b) High Speed Mushet.

High Speed (c) High Speed Midvale.

SAMPLE CALCULATIONS.

Average Power equals Average E.M.F. x Average I.

224 x 7.85 equals 1750 Watts.

Total Power equals Average Power x Time in Hours.

1750 x 15.11 equals 26.455 K.W.hrs.

Power per Pound equals Total ÷ No of Pounds.

26.455 ÷ 204.5 equals .1295

Time per Pound equals Total Time ÷ No of Pounds

15.11 ÷ 204.5 equals .074

Cost of labor per Pound equals Time per pound in hours x \$.33

.074 x \$.33 equals \$.0244

Cost of Power per Pound equals Power per pound x Cost per K.W.hr

.1295 x \$.0165 equals \$.00213

Total Cost per Pound equals Cost of Labor + Cost of Power.

\$.00213 + \$.0244 equals \$.02653

SAMPLE DATA SHEET.

LOW SPEED STEEL TOOL (a) ON 52" POND LATHE.

TIME	E.	I.	SPEED OF CUT
11-20	216	9	25
11-22	218	9	
11-24	216	9.1	Cut $1/2"$ Feed $1/64"$
11-26	215	10	
11-28	218	8	
11-30	220	7.5	
11-32	219	7.5	
11-34	220	7.5	
11-36	221	7.5	
11-38	222	7.5	
11-40	220	7.5	
11-42	220	7.5	
11-44	220	10	
11-46	222	10	
11-48	220	10	
11-50	222	9.8	
11-52	222	10	
1-02	220	6.5	25
1-04	218	6.8	
1-06	218	6.9	Cut $3/8"$ Feed $1/64"$
1-08	220	6.8	
1-10	220	6.9	25
1-12	218	6.9	
1-14	220	6.9	
1-16	220	6.8	
1-18	220	6.8	
1-20	220	6.8	
1-22	220	6.8	
1-24	220	6.8	
1-26	217	7	
1-30	217	7.1	
1-32	220	7	
1-34	220	7	
1-36	220	6.9	
1-38	216	6.8	
1-40	217	6.9	

Data from Test on High and Low Speed Steels.

No	Machine Tool	Cutting Tool	Job	Feed in inches	Cut in inches	Speed of cut ft/min	Metal Removed in Pounds	Power K.W/hr	Time	K.W. hrs Per Pound	Time in hrs Per Pound
1	52" Pond Lathe	Low Speed (a)	Locomotive Driver Axle	1/32	1/8	23.5	204.5	26.455	15 hr 7 min	.1295	.074
2	52" Pond Lathe	High Speed (a)	Locomotive Driver Axle	3/64	1/2	77.5	209.3	9.18	3 hr 33 min	.0438	.017
3	84" Pond Wheel Lathe	Low Speed (b)	Locomotive Drivers - 53 1/4"			4.4	265	18.49	6 hr 27 min	.0699	.0243
4	84" Pond Wheel Lathe	High Speed (b)	Locomotive Drivers - 53 1/4"	5/32	5/8	14	335	21.628	2 hr 8 min	.0646	.00637
5	Horizontal Boring Mill	Low Speed (a)	Cast Iron Journals	1/32	1/4	7 1/2	4.75	.784	42 min	.165	.156
6	Horizontal Boring Mill	High Speed (b)	Cast Iron Journals	5/256	1/4	36	4.75	.367	8.15 min	.0771	.0284
7	Vertical Boring Mill	Low Speed (a)	4-4" Tires Eng. Drivers		3/32	20	13.5	1.765	1 hr 33 min	.131	.115
8	Vertical Boring Mill	High Speed (b & c)	4-4" Tires Eng. Drivers		3/32	35	13.5	1.463	27.5 min	.108	.034
9	Coach Wheel Lathe	Low Speed (b)	Coach Wheel Tires		3/8	9.5	83	9.226	2 hr 43 min	.111	.033
10	Coach Wheel Lathe	High Speed (b)	Coach Wheel Tires	1/8	3/8	15	160	15.369	2 hr 31 min	.096	.0156
11	84" Pond Wheel Lathe	Low Speed (a)	78" Drivers	1/16	3/8	7	178	15.05	3 hr 58 min	.0845	.0222
12	84" Pond Wheel Lathe	High Speed (b)	78" Drivers	3/16	3/8	16.5	178	5.028	1 hr 52 min	.0282	.0105
13	Planer	Low Speed (a)	5 Driving Boxes	1/16	1/4	12.5	45	3.66	3 hr 15 min	.0815	.072
14	Planer	High Speed (a)	5 Driving Boxes	1/8	5/16	18	45	1.83	1 hr 5 min	.0406	.024



Data from Test on High & Low Speed Tool Steels

No	Machine Tool	Cutting Tool	Job	Feed in inches	Cut in inches	Speed of Cut in ft	Material Removed in Pounds	Power Per Kw/hr	Cost of Power Per Kw/hr	Time	Cost of Labor Per 1 lb of Metal	Total Cost Per 1 lb of Metal
1	52" Pond Lathe	Low Speed (a)	Locomotive Driver Axle	1/32	1/8	23.5	204.5	2645	2.13	15 hr 7 min	2.44	2.653
2	52" Pond Lathe	High Speed (a)	Locomotive Driver Axle	3/64	1/2	77.5	209.3	918	.024	3 hr 33 min	.559	.631
3	84" Pond Wheel Lathe	Low Speed (b)	Locomotive Drivers-53 1/4"			4.4	265	18.49	.115	6 hr 27 min	.803	.918
4	84" Pond Wheel Lathe	High Speed (b)	Locomotive Drivers-53 1/4"	5/32	5/8	14	335	21.63	.1066	2 hr 8 min	.114	.220
5	Horizontal Boring Mill	Low Speed (a)	Cast Iron Journals	1/32	1/4	7.5	4.75	.784	.273	42 min	.486	5.133
6	Horizontal Boring Mill	High Speed (b)	Cast Iron Journals	5/256	1/4	36	4.75	.367	.127	8 1/5 min	.945	1.072
7	Vertical Boring Mill	Low Speed (a)	4" Tires Eng. Drivers		3/32	20	13.5	1.765	.218	1 hr 33 min	3.84	4.058
8	Vertical Boring Mill	High Speed (b & c)	4" Tires Eng. Drivers		3/32	35	13.5	1.463	.181	27.5 min	1.135	1.316
9	Coach Wheel Lathe	Low Speed (b)	Coach Wheel Tires		3/8	9.5	83	9.226	.184	2 hr 43 min	1.313	1.497
10	Coach Wheel Lathe	High Speed (b)	Coach Wheel Tires	1/8	3/8	15	160	15.37	.1587	2 hr 31 min	.516	.674
11	84" Pond Wheel Lathe	Low Speed (a)	78" Drivers	1/16	3/8	7	178	15.05	.139	3 hr 58 min	.73	.869
12	84" Pond Wheel Lathe	High Speed (b)	78" Drivers	3/16	3/8	16.5	178	5.028	.0465	1 hr 52 min	.346	.389
13	Planer	Low Speed (a)	5 Driving Boxes	1/16	1/4	12.5	45	3.66	.134	3 hr 15 min	2.38	2.514
14	Planer	High Speed (a)	5 Driving Boxes	1/8	5/16	18	45	1.83	.0671	1 hr 5 min	.795	.862

* Cost of Power Per K. W. Hr = \$0.165
Cost of Labor Per Hour = \$3.33

Method of Obtaining Cost of Power

Item	Cost \$	%	Cost per mo. \$
Bldg.	15,000	Depreciation 3	37.50
Equip.	31,000	Depreciation 10	258.00
Coal, Oil & Waste			1400.00
Labor			650.00
Interest & Taxes	46,000	7	268.00
Water			100.00
Total Cost per Month \$2713.50			

Kilowatt-hours per Mo. at Switch-board, 166,560

$$\text{Cost per Kilowatt-hour} = \frac{2,713.50}{166,560} = \$0.0162$$

Pond Lathe

Job - Locomotive Driver Axle Turning & Fitting

Low Speed Tool (a)
Cut - $\frac{1}{16} \times \frac{1}{32}$

Speed - 23.5 ft. per min.

High Speed Tool (a)
Cut - $\frac{1}{2} \times \frac{3}{8}$

Speed - 77.5 ft. per min.

Total

Labor

Total

Labor

Power

Power

Cost per Pound Metal, Cents

2.75

2.5

2.0

1.75

1.5

1.25

1.0

.75

.5

.25

Wheel Lathe

Job - Turning down Engine Drivers

Low Speed Tool (b)

Cut -

Speed - 4.4 ft. per min.

High Speed Tool (b)

Cut - $\frac{5}{8} \times \frac{5}{32}$

Speed - 14 ft. per min.

Cost per Pound Metal, Cents

1
2
3
4
5
6
7
8
9

Labor

Total

Power

Labor

Power

Total

ADDITIONAL

ADDITIONAL

ADDITIONAL

ADDITIONAL

ADDITIONAL

ADDITIONAL

ADDITIONAL

ADDITIONAL

ADDITIONAL

ADDITIONAL

ADDITIONAL

Coach Wheel Lathe

Job - Turning down Coach Wheels

Low Speed Tool (b)

Cut - $\frac{3}{8} \times$

Speed - 9.5 ft. per min.

High Speed Tool (b)

Cut - $\frac{3}{8} \times \frac{1}{8}$

Speed - 15 ft. per min.

Cost per Pound Metal, Cents

1.5
1.4
1.2
1.0
.8
.6
.4
.2

Labor

Total

Power

Power

Labor

Total

Horizontal Boring-Mill
Boring Cast Iron Journals

Low Speed Tool (al)
Cut - $\frac{1}{4} \times \frac{1}{32}$
Speed - $7\frac{1}{2}$ ft. per min.

High Speed Steel
Cut - $\frac{1}{4} \times \frac{5}{256}$
Speed - 36

5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5

Cost per Pound Metal, Cents

Total

Labor

Power

Power

Labor

Total

10000 10000 10000
 10000 10000 10000
 10000 10000 10000

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Wheel Lathe

Job - Turning down Engine Drivers

Low Speed Tool (b)
Cut - $\frac{3}{8} \times \frac{1}{16}$

Speed - 7 ft. per min.

High Speed Tool (b)
Cut - $\frac{3}{8} \times \frac{3}{16}$

Speed - 16.5 ft. per min.

Cost per pound Metal removed, Cents

1
2
3
4
5
6
7
8
9

Labor

Total

Power

Labor

Total

Power

July 1334M

200000 200000 200000 200000

100000 100000 100000

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100000

100000 100000 100000 100000

Planer

Job - Facing Driver Boxes

Low Speed Tool (a)
Cut - $\frac{1}{4}$ " x $\frac{1}{16}$ "

Speed - 12.5 ft. per min.

2.7

Cost per pound Metal, Cents

2.4

2.1

1.8

1.5

1.2

.9

.6

.3

Labor

Total

Power

High Speed Tool (b)
Cut - $\frac{5}{16}$ " x $\frac{1}{8}$ "

Speed - 18 ft. per min.

Labor

Total

Power

Notes

1000 ft. 1000 ft. 1000 ft.

1000 ft. 1000 ft. 1000 ft.

1000 ft. 1000 ft. 1000 ft.

1000 ft.

1000 ft.

1000 ft.

1000 ft.

1000 ft.

1000 ft. 1000 ft. 1000 ft.

1000 ft. 1000 ft. 1000 ft.

Vertical Boring-Mill Job- Boring Engine Driver Tires

Low Speed Tool (a)
Cut - $\frac{3}{32}$

Speed - 20 ft. per min.

High Speed Tool (b) & (c)
Cut - $\frac{3}{32}$

Speed - 35 ft. per min.

Cost per pound, Cents

Total

Labor

Power

Total

Labor

Power

1904-05-1905-1906
 1906-1907-1908-1909
 1909-1910-1911-1912

1904-1905 1906-1907
 1908-1909 1910-1911
 1912-1913 1914-1915

1906-1907 1908-1909
 1910-1911 1912-1913
 1914-1915 1916-1917

1904

1905

1906

1907

1908

1909

1910-1911-1912-1913-1914-1915-1916-1917

1918-1919-1920-1921-1922-1923-1924-1925

1916-1917

Power Taken by Motors

Test No.	Machine Tool	Character of Job	Average Power Input, Roughing Cut, K.W.	Max. Power Input during Job, K.W.	Rating of Motors, H.P.
2	52" Pond Lathe	Heavy	6.4	8.05	6
4	84" Pond Wheel Lathe	Heavy	13.75	19.98	20
6	Small Hor. Boring Mill	Very Light	3.04	3.1	7.5
8	Large Ver. Boring Mill	Light	3.04	4.1	7.5
10	Coach Wheel Lathe	Medium	9.95	18.6	15
12	84" Pond Wheel Lathe	Heavy	11.68	19.26	20
14	Planer 42"x42"x12'	Light	2.82	5.5	7.5





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